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NAVAL WAR COLLEGE
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THE PROBLEM OF THEATER BALLISTIC MISSILES: UNRESOLVED DILEMMA FOR THE OPERATIONAL COMMANDER

by

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A paper submitted to the Faculty of the Naval War College in partial satisfaction of the requirements of the Department of Operations.

The contents of this paper reflect my own personal views and are not necessarily endorsed by the Naval War College of the Department of the Navy.

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CHAPTER I

INTRODUCTION

Overview

As "lessons learned" from the Gulf War emerge, military planners must caution themselves against over confidence or drawing the wrong conclusions. During the war and its immediate aftermath, analysts extolled the virtues of the Patriot missile and its role in rendering Saddam Hussein's SCUD missiles almost completely useless. Now, wiser minds and clearer heads appear to be rethinking the problems ballistic missiles caused the operational commander, Saddam's relatively antiquated ballistic missile technology and the prospects for the use of ballistic missiles in the future. This essay analyzes the state of world wide ballistic missile technology, the complexity ballistic missiles add to the operational commander's planning, and the systems devised for dealing with this difficult weapon.

History

Ballistic missile technology dates to World War II when Hitler's scientists developed the V-2 "Buzz bombs." These terror weapons, rocket boosted at launch, followed a curved

ballistic trajectory. After rocket motor burn out, the effects of gravity caused the weapon to arc downward in a curved trajectory. In its infancy, rocket motor technology limited range and payload. Before the advent of inertial guidance systems, the ballistic missile's landing site was virtually unpredictable and the weapon had the limited role of terrorizing citizens of London with random death and destruction.

Saddam Hussein's SCUD missiles represent an increase in accuracy and sophistication yet these weapons can hardly be called state of the art. The Soviet Union developed the first SS-1B SCUD A in the mid-1950s. By 1965, an improved variant, the SS-1C or SCUD B became operational. These missiles varied in length from between 31 to 33 feet with a 3 foot diameter. Liquid propellant powered boost and the payload or warhead section remained attached to the propellant section throughout flight. Launch weight averaged around 14,000 pounds and the Soviets achieved ranges up to 180 NM. The corrosive nature of the liquid propellant dictated fueling shortly before launch and a time and manpower intensive pre-launch targeting procedure made these weapons difficult to use on the battlefield.[1] Despite these drawbacks and compounded by questionable accuracy, Soviet deployment of SCUDs on mobile

transporter-erector-launchers began to affect operational planning. SCUDs posed a threat and air assets had to be dedicated to find and destroy them on the ground in a fight.

Iraqi SCUDs

Saddam Hussein's SCUDs closely resembled their Soviet forbearers. The Iraqi's have, however, made improvements including an increase in fuel and a subsequent maximum range increase of from 400 to 600 NM. This range increase came at the expense of payload (warhead) size, believed to be up to 1,000 pounds of high explosive, chemical or biological agents, or a nuclear device. But increasing the range of a ballistic missile makes it a tougher target for interceptors. As range increases, terminal velocity climbs. The speed of an Iraqi Al-Hussein missile is believed to be Mach 6 (while an ICBM may reach Mach 24 on reentry, thus making it an impossible target for Patriot).[2]

Still, the SCUD's old technology, size, and accuracy (estimated to be no greater than one mile), mark it as a museum piece when compared to newer ballistic or cruise missiles. At the height of the Gulf War, Time Magazine quoted a weapons expert who described the SCUD as "unwieldy and inaccurate, practically antique, a dinosaur . . . . "[3]

Modern Cruise Missiles

By contrast, a modern cruise missile like TOMAHAWK weighs only 2,650 pounds (about 1/6 of a SCUD), and travels at a speed just below Mach 1 (compared to SCUD's Mach 6). The modern cruise missile, however, has a crucial accuracy advantage as demonstrated during the Gulf War. While SCUDs promise accuracy in terms of miles, TOMAHAWK offers accuracy in terms of feet. U.S. Navy personnel familiar with TOMAHAWK contend that it can "fly through a window" of the target building. TOMAHAWK's accuracy is a function of its high cost, high technology navigation system, a part of which is called TERCOM or terrain contour matching. This process involves digital comparison of geographic scenes of the target approach path stored in the missile with scenes of the terrain being overflown. This scene matching technology requires the conversion of detailed high definition overhead imagery of the flight path "scene" into digitized, computer storable memory. All this drives up cost significantly.[4]

Advanced Ballistic Missile

The U.S. Army's front line ballistic missile, Pershing II, uses a radar seeker that activates at about 50,000 feet. The radar image of the target is compared with a pre-stored,

digital scene of the target obtained by satellites prior to launch. Like TOMAHAWK, this scene matching routine allows for terrific accuracy. Pershing II has demonstrated an accuracy of less than one hundred feet. Like the SCUD, Pershing is a mobile, long range (1,000 NM), fast (Mach 12) ballistic missile.[5]

Attraction of Ballistic Missiles to the Third World

Ballistic missiles are available, relatively inexpensive, easy to operate, require little or no external technological support (no satellite data), and they are practically invulnerable to shoot down (Patriot being the only known defensive system against SCUD). An attribute comparison of TOMAHAWK and SCUD at Appendix A helps show why ballistic missiles appeal to Third World leaders.

Third World leaders value the prestige associated with ballistic missiles. These weapons signify modernization, sophistication, and allow the owner to claim acceptance among the superpowers. Ballistic missiles give Third World leaders long range, penetrating weapons that can deliver weapons of mass destruction.

Ballistic Missile programs are relatively inexpensive, especially when compared to the costs of cruise missiles or

creating an air force capable of long range strikes and defending the homeland. The cost of modern, high performance fighter and strike aircraft, their weapons, pilot training, and air defense systems often make ballistic missiles an attractive alternative or force multiplier. As the former Soviet Union and former Warsaw Pact nations seek hard currency, one can expect Third World customers clamoring for off-the-shelf ballistic missiles or the technical tools and scientists to help create indigenous programs for both missiles and the warheads equipped with weapons of mass destruction.

CHAPTER II

BALLISTIC MISSILES: OPERATIONAL NIGHTMARE

Once ballistic missiles are a known threat to the theater commander, enemy actions (especially launches that result in significant friendly damage) can cause the commander to reallocate resources to finding and eliminating the ballistic missile threat. Finding mobile ballistic missile launchers can become a particularly difficult, resource and time consuming problem that has the potential to disrupt operations. According to an Aviation Week and Space Technology story of the Gulf War, "one Pentagon official said the allies lost about a full day during the first week of the war 'chasing SCUDs'."[6]

Intelligence

Mobile ballistic missile launchers compound the intelligence efforts of the operational commander. During Operation Desert Shield, the vastness of the inhospitable desert, the relatively small size of the SCUD launchers, our lack of ground observers in the Iraqi desert and the limitations of our space based sensors left most SCUDs unlocated prior to the commencement of hostilities. Although intelligence agents were used to infiltrate Iraqi lines in the Kuwaiti Theater of Operations (KTO),[7] the size of the desert,

the severity of the climate and the relatively small size of the SCUD launch platform militated against the use of human intelligence (HUMINT) to locate the missiles disbursed to the desert. Space assets were prioritized to collect information on enemy concentrations in the Kuwaiti Theater of Operations (KTO) and in command and control nodes such as Baghdad and Basra. Even when satellite assets could collect over the Iraqi desert the relatively small SCUD launchers could only be found and targeted by some of our more sophisticated satellites. A truck found in the desert by space reconnaissance could not be assumed to be a SCUD launcher since some Bedouins had vehicles in the desert. An unclassified estimate of the resolution required to find and target a SCUD is at Appendix B.

Ground based air reconnaissance systems did not solve the hunt for the desert SCUDs either. Prior to the start of the war, unarmed reconnaissance flights over Iraqi territory could have exposed pilots to hostile fire. The risk of giving Saddam Hussein additional hostages was considered to be too great to permit fixed wing reconnaissance of the desert. After the war commenced, the inventory of available aircraft capable of collection, already severely reduced by cancellation of the SR-71 program, quickly became overtaxed in Bomb Damage Assessment (BDA) missions.

Warning, Locating, and Targeting

Several U.S. sensors and systems capable of providing information on ballistic missiles in flight currently exist. Generally, satellite systems and extremely long range radars can provide alertment and warning. Since these systems are controlled at the national level, the operational commander may find he is merely a "user" of system data. Communications channels must be devoted to providing warning information to the operational commander on a real time basis. The warning provided may be short and inaccuracies may force the operational commander to shut down operations in large areas after alertment of imminent ballistic missile attacks. During Desert Storm, Defense Support Program (DSP) satellites, designed to detect the infrared signature of Soviet ICBMs at launch, had to be repositioned and readjusted to detect the smaller plumes of the SCUDs. DSP gave Patriot batteries and potential large area targets some warning time (about 5 minutes).

These same satellites provided locating data. By tracing the infrared signature of the SCUD back toward its origin, a potential launcher search area could be established. J-STARS (Joint Surveillance Target Attack Radar System), a system that can track moving targets on the ground, could then search the

anticipated SCUD launch area from the sky in an effort to locate the moving launcher.[8] J-STARS hands-off targeting data to strike planners.

Unpracticed, time constrained and using limited assets at the outer limits of their intended design, U.S. forces achieved some success in detecting, targeting, and ultimately calling in air strikes to destroy some desert SCUDs. But with only two J-STARS aircraft in theater, General Schwarzkopf naturally wanted to focus their efforts on the larger concentrations of enemy activity in the KTO.[9] The operational commander primarily used J-STARS to keep informed on the movements of the Iraqi Army.

Once ballistic missile launch sites are targeted, the operational commander needs to allocate his limited resources to strike. Aviation Week and Space Technology reported that early in the war, as a result of SCUD attacks, "the hunt for Iraqi SCUDs now became a military necessity" and that commanders felt "pressure to divert aircraft from other targets to search out and destroy"[10] the SCUDs. As the lethality of the ballistic missile increases the cost in men and material the operational commander is forced to endure, one can speculate that the resources devoted to finding and eliminating the ballistic missile threat would also increase.

Cruise Missiles As Counter Weapons

Strike aircraft in the Gulf attacked the SCUD sites, but cruise missiles could offer an alternative counter weapon. Unfortunately, the amazing accuracy of cruise missiles is a function of detailed advanced mission planning against fixed targets. Mission planning costs are held down by digitizing imagery along routes to fixed targets that offer a high pay-off: command, control and communications nodes for example. Targeting mobile systems with the cruise missiles currently in use would require massive imagery collection, digitization, and flight path planning efforts that could potentially drive weapon costs to an unaffordable level. Although cruise missile strikes on fixed launchers remains viable, striking mobile ballistic missiles with cruise missiles such as TOMAHAWK is not an option the operational commander currently has or can expect to have in the near term.

Assault Troops

Finally, the operational commander may choose to take the mobile ballistic launcher with troops. Depending upon the defensive manning and location of the launch site, the cost of such an adventure could range from a few special operations troops on a sabotage mission to a larger airborne or

conventional infantry force in direct assault. This option increases the potential for prisoners and casualties and may drain resources from other fronts. During Desert Storm, Secretary of Defense Dick Cheney reportedly advocated an early sweep through the unprotected desert by ground troops. Cheney believed an assault force could eliminate the SCUDs facing Israel.[11]

Ground to Air

Once ballistic missiles are launched toward the operational commander the relatively short time to impact defies any shoot down but that of the most practiced, high speed system. Even if launch can be detected, trajectory calculations to predict an impact point take time. A Mach 6 SCUD launched at maximum range or 600 NM will impact in just 10 minutes.

The only proven effective ground to air anti-ballistic missile system, Patriot, the "SCUD buster" hero of the Gulf War, is now officially credited with countering 70% of the SCUDs fired at the Saudi Arabian theater and 40% of the SCUDs fired at Israel.[12] An Israeli group claims that "Patriot was not able to destroy any SCUD warhead."[13] Still others cite the 28 American servicemen and women killed by a SCUD in a Patriot

protected barracks as proof of the need for improved anti-ballistic missile (ABM) weapons. Some experts now believe the barracks tragedy was the result of an untimely Patriot computer failure, pointing out the infallibility of these systems.[14] Patriot has other problems too. Unclassified sources grant the Patriot missile a 50 NM range and 70,000 feet altitude capability. This relatively narrow performance envelope could easily expose friendly forces to crashing ballistic missile and ABM debris after a successful intercept.

Force Disposition

Adequacy of defensive systems such as Patriot could drive the operational commander's friendly force disposition plan. According to Lieutenant General Charles A. Horner, Central Command's Air Component Commander during the Gulf War, Patriot only had to defend relatively few large military concentrations. According to Horner, there "wouldn't be enough Patriots in the world to defend" a more disbursed allied force.[15]

Surface to Air (Navy)

Even the Navy's first line fleet air defense system, AEGIS, lacks the capability to counter the steep dive angle of

a ballistic missile. Like most sea based systems, the SPY-1 radar of AEGIS concentrates search and computer processing assets nearer the surface of the ocean in an effort to optimize system performance against anti-ship cruise missiles. The long range radar (over 200 NM) could be used in a ballistic missile warning role. However, system modifications would be necessary before AEGIS could counter a ballistic missile.

Air-To-Air

Air-to-air anti-ballistic missile systems have shown promise. Systems such as the advanced medium-range air-to-air missile (AMRAAM) are postulated to be effective against SCUD type weapons.[16] This fire and forget weapon would still require a warning network, real-time targeting (pointing) procedures, and weapons platforms continuously aloft in the anticipated ballistic missile target area.

Ballistic Missiles: Force Multiplier For The Enemy

The existence of ballistic missiles in theater, therefore, greatly compounds the operational commander's reconnaissance and targeting plans, strike plans, resource allocation and force disposition. Additionally, the proliferation of ballistic missiles and the potential for nuclear, biological or

chemical weapons makes virtually every potential theater subject to attack by weapons of mass destruction. As a result, the operational commander's logistics plan must include adequate supplies of personal protective equipment, decontamination equipment, medications, etc. In populated areas, the operational commander must expect to become involved in civil defense measures and be prepared for mass casualties. The proliferation of ballistic missiles and weapons of mass destruction means the likelihood that U.S. forces will ever go into battle again without personal protective equipment is decreasing. The operational commander must be prepared for the terrible specter of mass casualties.

This ability to inflict mass casualties makes ballistic missiles and weapons of mass destruction attractive to world leaders who see these as assets that can tip the balance of power in their own favor. In early 1988 Saddam Hussein demonstrated his power over Iran. During a 190 Al-Hussein (modified SCUD) missile bombardment of Iran, Iraq inflicted more than 2000 Iranian casualties, disrupted the Iranian war economy and forced a partial evacuation of Tehran, the capital.[17]

General Horner put it bluntly, calling SCUD "a lousy weapon, a terror weapon."[18] This capacity to create terror and

change the course of pre-hostility negotiations, war, or post war settlements forces the operational commander to make ballistic missiles and the associated weapons of mass destruction priority targets. When Saddam Hussein unleashed his SCUDs on Israel during the Gulf War, coalition leaders feared that an Israeli retaliatory response would drastically change the nature of the war, the coalition goals, perhaps the membership of the coalition itself. An Israeli response that escalated the war could have caused Arab coalition members to balk.

Thus, ballistic missiles -- terror weapons -- can be escalatory, forcing a change in the scope, direction, objective and intent of the war. Ballistic missiles strike at the very principles of war, forcing the operational commander facing ballistic missile attacks to consider widening his objectives, disbursing rather than massing his force, defending rather than attacking and allocating additional resources to combat what may be a secondary objective (violating the principle of economy of force).

One can easily imagine a hypothetical Gulf War scenario involving hundreds or even thousands of coalition casualties due to hits from Iraqi SCUDs with chemical warheads. Pressure to eliminate Saddam Hussein and his weapons would grow,

primarily from nations that suffered the greatest casualties, but also among the fearful neighbors such as Saudi Arabia and Israel. President Bush's ability to call off the offensive once Iraqi troops were forced out of Kuwait may have been impacted by political pressure to "rid the region of the menace, once and for all."

Our operational commanders already envision such troublesome situations. The Deputy Commander of Central Command, Major General James R. Ellis, lists ballistic missiles and weapons of mass destruction as critical threats to stability due to their "potential to escalate war."[19] Admiral Mike Boorda, Commander-in-Chief, NATO Forces Southern Europe, lists Libya's potential ballistic missiles and weapons of mass destruction as the number one threat to stability in his theater.[20]

CHAPTER III

WORLD WIDE CAPABILITIES AND THE FUTURE

Overview of Ballistic Missile and Weapon of Mass Destruction Proliferation

Besides the U.S., Britain, France, China, and the former Soviet Union, as many as sixteen nations currently have ballistic missile programs. Many more are seeking to create ballistic missile programs. Besides buying systems "off the shelf" and reverse engineering existing systems, there is growing fear that scientists once employed in the Soviet Missile Program will work as mercenaries for Third World nations -- especially nations with the hard currency to pay.

A chart depicting Third World nations and the status of their ballistic missile and weapon of mass destruction programs is at Appendix C.

Chemical Proliferation

Chemical weapon programs reside in as many as fourteen Third World nations. Major General Ellis sees few obstacles to the development of chemical weapon programs in Third World nations saying, "any nation with a fertilizer industry can have chemical weapons if they want to."[21]

Nuclear Proliferation

Many fear nuclear proliferation, already a serious problem before the break up of the Soviet Union, may expand further in the near term. Besides the super powers, Israel is already known to have a nuclear arsenal. Pakistan and India may be within a year or two of developing nuclear weapons, according to CIA Director Robert Gates, and North Korea may be only a matter of months away from nuclear capability.[22] Other nations are striving to achieve nuclear programs. The break up of the Soviet Union offers the risks of 100,000 unemployed nuclear scientists and engineers and over 27,000 nuclear weapons with various controls and safeguards of questionable certainty.[23]

Even before the break up of the Soviet Union, Secretary of State George Schultz said in 1988, "bad as the proliferation of chemical weapons and ballistic missiles is, nuclear proliferation poses even graver threats to international stability."[24]

Biological Proliferation

Proliferation of the technology to produce Biological Weapons (BW) continues. U.S. intelligence experts list Syria, North Korea, Libya, Iran, Israel and Taiwan as among nations with BW capabilities or potential. Although slightly less

threatening than nuclear weapons, biological weapons can be produced at less cost using an infrastructure that would make detection unlikely. These weapons can inflict massive casualties over wide areas. Ballistic missiles provide the stand off attack capability best suited to biological weapons. Casualty estimates for weapons of mass destruction are at Appendix D.

Technology Transfer

The state of ballistic missile technology continues to improve. The poor accuracy of the SCUD has been attributed both to its 1950's technology and the careless procedures of the Iraqi Army.[25] Despite efforts to slow the export of advanced technologies, we live in a world where nations seem to have an almost insatiable appetite for weapons that give them an advantage over their neighbors. Many of Iraq's sophisticated weapons programs, including its nuclear weapons development program, prospered using western technology.[26] It seems almost too optimistic to believe that technology transfer agreements can keep ballistic missile precision guidance technologies away from determined customers for very long. The Director of Naval Intelligence takes a dim view of attempts to limit technology transfer saying "international export control

regimes governing the sale of technology related to nuclear, chemical and biological weapons and missile related technology has proven largely ineffective."[27]

Space Programs

A growing number of nations participate in combined space ventures, possess indigenous space programs, or plan future space systems. The lines between military and civilian space programs continue to blur. India recently developed a long range ballistic missile using the first stage of the national satellite launch rocket.[28]

As more nations become involved in space based, reconnaissance and targeting, the technology of these systems can be expected to proliferate and improve. Had Saddam Hussein had access to even relatively crude satellite imagery, he may have been able to detect the coalition's surprise western swing through the desert. Perhaps, with satellite support, Saddam could have redeployed his forces or retargeted his SCUDs in order to punish coalition forces. Appendix E depicts nations with space programs.

CHAPTER IV

CONCLUSIONS

The Gulf War demonstrated the difficulty even a relatively old and unsophisticated ballistic missile causes an operational commander. Ballistic missiles in theater impact every facet of the operation. The proliferation of ballistic missiles, already widespread, can be expected to continue. The technology to improve the capability of existing systems and to build new, more accurate weapons has already been put to work in U.S. systems such as Pershing II and TOMAHAWK. Efforts to stem the flow of technology to potential adversaries have met with only mixed results.

U.S. forces demonstrated a limited capability to find and destroy widely disbursed, mobile ballistic missiles during the Gulf War. Satellite imagery systems failed to meet demand and fixed wing systems, forbidden from conducting pre-war overflights of Iraq, became totally devoted to BDA missions once the war began. Relatively few mobile SCUD launchers were located before the war started. Despite the use of the nation's most sophisticated systems, DSP and J-STARS, targeting launchers that had already fired one missile proved problematic. Defense against SCUDs in flight relied solely upon Patriot.

Thankfully, U.S. operational commanders have yet to demonstrate the ability to survive and fight in a nuclear, chemical or biological environment. Proliferation of these weapons argues for continued training and readiness.

This essay helps explain the operational difficulties posed by ballistic missiles and weapons of mass destruction. As long as our warfighting counters to these weapons remain inadequate (See Appendix F), the proliferation and possible use of ballistic missiles among our Third World adversaries will be an enduring problem.

The National Command Authority (NCA) has already recognized our vulnerability and emphasized the importance of "developing systems capable of defending against limited ballistic missile strikes."[29] Additionally, the Director of the Central Intelligence Agency lists the assessment of the Commonwealth of Independent States, "including proliferation of weapons of mass destruction and control of nuclear weapons" and "the spread of nuclear chemical, biological weapons and ballistic missiles worldwide" as the agency's top two priorities.[30] The military services now need to get on with the difficult problem of developing the means of negating the threat of ballistic missiles and weapons of mass destruction.

APPENDIX A

ATTRIBUTE COMPARISON TOMAHAWK TO SCUD

	TOMAHAWK	SCUD (Iraqi Variant)
Length	18ft 3 inches	31 to up to 40 feet
Diameter	20.4 inches	36 inches
Weight	2,650 lbs	14,000 lbs
Range	1,500 NM (land attack)	Up to 600 NM
Warhead	1,000 lbs	Less than 1,000 lbs
Speed	600 KTS (Mach 1)	Mach 6
Warhead	Conventional or nuclear	Conventional, nuclear chemical, biological
Technology	High	Low
Trajectory	Parallel to earth	Steep dive angle
Cost	High	Low
Availability	Not exported	Available from international arms dealers
Accuracy	Within a few feet	Within a mile
Vulnerability to Shoot Down	Medium to High	Relatively low (Patriot is only known)

Sources: **The Almanac of Seapower 1991, Jane's Pocket Book of Missiles 1975, Aviation Week and Space Technology 28 January 1991.**

APPENDIX B

REQUIRED GROUND RESOLUTIONS FROM COMMERCIAL OBSERVATION SATELLITES (IN METERS)

TARGET	DETECTION	GENERAL ID	PRECISE ID	DESCRIPTION	TECHNICAL ANALYSIS
Bridges	6	4.5	1.5	1	0.3
Radar	3	1	0.3	0.15	0.015
Supply Dumps	1.5-3	0.6	0.3	0.03	0.03
Troop Units	6	2	1.2	0.3	0.15
Airfield Facilities	6	4.5	3	0.3	0.15
Rockets/ Artillery	1	0.6	0.15	0.05	0.045
Aircraft	4.5	1.5	1	0.15	0.045
SSM/SAM Sites	3	1.5	0.6	0.3	0.045
Surface Ships	7.5-15	4.5	0.6	0.3	0.045
Vehicles*	1.5	0.6	0.3	0.06	0.045
Minefields	3-9	6	1	0.03	0.09
Ports and Harbors	30	15	6	3	0.3
Railroad Yards	15-30	15	6	1.5	0.15
Roads	6-9	6	1.8	0.6	0.4
Urban Areas	60	30	3	3	0.75
Terrain	--	90	4.5	1.5	0.75

Detection: Location of a class of units, object or activity of interest.
General ID: Determination of general target type.
Precise ID: Discrimination within target type of known types.
Description: Size/dimension, configuration/layout components, equipment count, etc.
Technical Analysis: Detailed analysis of specific equipment.

*** A mobile SCUD launcher would be just larger than a vehicle but smaller than a SAM site.**

Source: Ann M. Florini, "The Opening Skies: Third-Party Imaging Satellites and U.S. Security," International Security, Fall 1988.

APPENDIX C

THIRD WORLD BALLISTIC AND WEAPONS OF MASS DESTRUCTION PROGRAM[31]

COUNTRY	BALLISTIC MISSILE	CHEMICAL WEAPON	BIOLOGICAL WEAPON	NUCLEAR WEAPON
Afghanistan	Yes			Planned
Argentina	Yes			Possible
Brazil	Yes	Possible		
Burma		Likely		
Egypt	Yes	Likely		
Ethiopia		Likely		
India	Yes	Likely		Yes
Indonesia	Planned	Possible	Possible	
Iran	Yes	Yes	Likely	
Iraq	Subject	To Post	War	Sanction
Israel	Yes	Likely	Likely	Yes
Korea, North	Yes	Likely	Likely	Possible
Korea, South	Yes	Likely		
Libya	Yes	Likely		
Pakistan	Yes	Likely		Likely
Saudi Arabia	Yes	Possible		
South Africa	Yes	Possible		Likely
Syria	Yes	Likely	Likely	
Taiwan	Yes	Likely	Likely	
Thailand	Possible	Likely		
Vietnam	Possible	Likely		
Yemen	Yes			

APPENDIX D

EFFECTIVENESS OF BW IN AN ATTACK AGAINST CIVILIANS

Type of Warhead	Without Civil Defense		With Civil Defense	
	Dead	Injured	Dead	Injured
Conventional (One ton explosive)	5	13	2	6
Chemical (300 kg of sarin)	200-3,000	200-3,000	20-300	20-300
Biological (30 kg of anthrax)	20,000-80,000	0	2,000-8,000	0
Nuclear (20 kiloton device)	40,000	40,000	20,000	20,000

Assumes one missile with throwweight of one ton aimed at large city with average population density of 30 per hectare. Assumes that civil defenses reduce casualties from conventional and nuclear explosions by a factor of two, and casualties from chemical and biological weapons by a factor of ten.

Source: Adam Kearney, "Re-evaluating the BWC, The Changing Threat of Biological Weapons," Harvard International Review, Spring 1992.

APPENDIX E

NATIONAL SPACE EFFORTS

First Echelon Space Nations

Manned Space Program	United States
ASAT Capability	Russia
Space Station or Shuttle	

Second Echelon Space Nations:
(Level 3 Plus: Indigenous or Cooperating Space Launch Programs, Developing Satellites and Launch Vehicles)

China
Brazil
France
United Kingdom
India
Israel
Japan
Spain
Germany

Third Echelon Space Users:
(Level 4 Plus: Purchase Satellite Imagery or Lease Communication Channels)

Iran
Pakistan
Libya

Fourth Echelon Space Users:
(Planned Space Launches or Programs)

Argentina
Indonesia
Taiwan
South Korea
South Africa

APPENDIX F

U.S. MILITARY OPERATIONAL CAPABILITY AGAINST BALLISTIC MISSILES

Locating	Significant
Targeting	Some
Warning	Significant (DSP) (Range Dependent)
Ground-to-Air	Some (Patriot)
Surface-to-Air (Navy)	None
Air-to-Air	Projected (AMRAAM)

NOTES

1. Unclassified sources on SCUD include Jane's Weapon Systems 1977, Jane's Pocket Book of Missiles 1975, and Nuclear Weapon Fact Book by Christopher Campbell.

2. Ibid, SCUD characteristics. SCUD and ICBM speeds from Aviation Week and Space Technology January 28, 1991, p.27 and 28.

3. Time Magazine, January 28, 1991, p.23.

4. Tomahawk Characteristics from Christopher Campbell, Nuclear Weapons Fact Book and The Almanac of Seapower 1991.

5. Pershing II data from Christopher Campbell, Nuclear Weapons Fact Book.

6. Aviation Week and Space Technology, January 28, 1991, p.20.

7. Bob Woodward, The Commanders, p. 268.

8. Aviation Week and Space Technology, January 28, 1991, p.19-20 and February 11, 1991, p.19. Unclassified sources do not reveal weather OTH-B or ROTHR assets contributed to SCUD warning. These assets may have future application as warning/alertment systems.

9. op cit, Woodward, p.369.

10. Aviation Week and Space Technology, January 28, 1991, p.20.

11. op cit, Woodward, p.309.

12. Eric Schmitt, "Army Cuts Back Its Estimate on Patriot Missiles's SCUD Toll, The New York Times, April 8, 1992, p. A11.

13. Eliot Marshall, "Patriot's Effectiveness Challenged," Science, p. 791.

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14. Denise L. Almond, Desert Score.

15. David A. Fulghum, "Desert Storm Highlights Need For Rapid Tactical Intelligence," Aviation Week and Space Technology, February 11, 1991, p.19.

16. Aviation Week and Space Technology, February 25, 1991, p.19.

17. W. Seth Carus, "Ballistic and Cruise Missile Proliferation in the Third World," Hearing before the Subcommittee on Defense Industry and Technology of the Senate Armed Services Committee, May 2, 1989, p.44.

18. op cit, Fulghum, p.18.

19. Major General James R. Ellis, Lecture before the U.S. Naval War College, April 2, 1992.

20. Admiral J. M. Boorda, Lecture before the U.S. Naval War College, March 30, 1992.

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23. William C. Potter, "Exports and Experts: Proliferation Risks From the New Commonwealth," Arms Control Today, January-February 1992, pp. 32-35.

24. George P. Schultz, "Proliferation and the Third World," Arms Control Update, July 1988, p.2.

25. Bob Woodward, The Commanders, p. 285.

26. Eliot Marshall, "How Western Technology Aided Iraq's War Machine," Science, February 1, 1991, p.512.

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27. Rear Admiral Edward D. Sheaffer, USN, Statement before the Seapower, Strategic, and Critical Materials Subcommittee of the House Armed Services Committee, February 5, 1992, p.73.

28. Martin Navias, Ballistic Missile Proliferation in the Third World, p.16.

29. Bush, George, The National Security Strategy of the United States, 1991, p.3.

30. Sciolino, Elaine, "CIA Chief Rejects Push for Change," The New York Times, April 2, 1992, p.D22.

31. Chart compiled using the following sources:
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